Hubble Space Telescope

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

Alternate End of Mission Concepts Presentation to the OS/SEUS Joint Meeting

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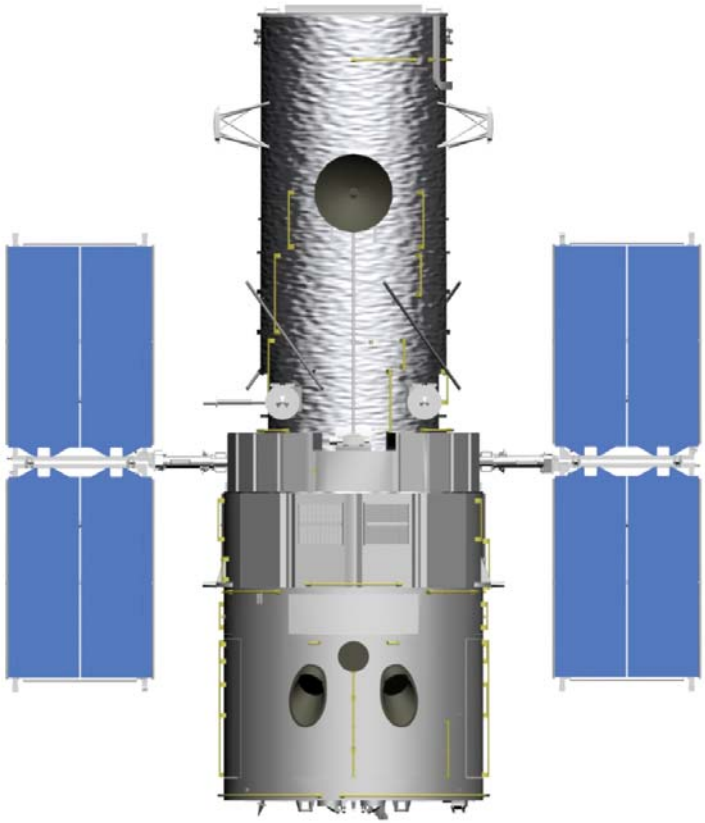
THE HST END OF LIFE



Original HST mission life 15 years with 3 year servicing centers and return to earth via STS. *1990 to 2005 Mission*

Replan allowed for Mission life after last servicing mission till 2010 with return on the STS. *1990 to 2005 Mission*

Congressional direction for alternate mission scenarios led to a propulsion system study early in 2003. *Potential for extended Mission*

CHARTER

"…extend the life of the telescope by use of an upper stage propulsion system to allow for disposal of the system without requiring an additional STS retrieval mission."

Evaluate the feasibility, utility, cost, and risk of adding an upper stage propulsive system to the HST. The specific analyses shall include:

Required performance of the element for multiple options
Periodic orbit altitude maintenance, and
Re-entry at end of life into a limited safe area of the ocean, or
Boost of the telescope at end of life to a high altitude disposal orbit
Size of the propulsion stage for each of the options
Controllability of the HST/upper stage during propulsive events

Tasking was to MSFC as a continuation of the previous work on STS stages for Code M and in support of the proposed SIM launch on the STS for Code S.

CONSTRAINTS

Upper stage should be comprised of components that are currently TRL 7, or higher.

The upper stage shall not require telemetry or power from the HST to effect propulsive burns, but HST excess power will be available for upper stage battery trickle charge.

Structural limitations of the HST shall not be exceeded by the upper stage propulsive force.

The attached propulsion upper stage may not degrade the performance of the HST during normal science operations (with the exception of settling time after slew and terminator passage).

The propulsion upper stage is to be secured to the HST using existing HST interfaces.

Propulsion upper stage shall be 3 axis controlled during propulsive burn(s).

The HST shall be in a cooperative stabilized attitude (e.g., gravity-gradient mode) during all phases of proximity and docking operations.

The existing budget for the HST program forms the basis for cost estimates. All options should be rated in terms of the additional costs incurred over the present budget plan.

As a goal, the overall mission reliability should be as high as the presently planned HST retrieval via the STS.

ADDITIONAL CONSTRAINTS FOR SPECIFIC LAUNCH OPTIONS

Shuttle Option

The propulsion upper stage system is to be transported to the HST via the STS.

Existing (and previously) STS qualified upper stages will be evaluated for potential use. An upper stage developed from previously qualified subsystems will be also evaluated.

Near STS qualified stages will be evaluated including the ISS ICM and ISS Propulsion Module.

Expendable Launch Vehicle Option

The propulsion upper stage is to be transported to the HST via U.S. ELV

Current inventory U.S. expendable propulsion upper stages will be evaluated.

Foreign developed propulsion stage(s) is to be considered. (For instance, Progress supply capsules presently used for the ISS)

Autonomous rendezvous and docking (ARD) systems shall be required. ARD assumed to be TRL 8 NLT 2006 (for 2010 launch).

CHANGING ENVIRONMENT

Columbia Accident

No more discussion of HST Retrieval via STS at end of life

Much more concern for safety of crew in any servicing mission

STS may not be available to accomplish SM4

STS may not be available to come to the “rescue” of HST

Is there any other option for rescue

Black Committee

No information relating to end of life

Bahcall Committee

No information directly relating to end of life

Ought to look into competitively evaluating the science of an SM5 mission vice programs not yet selected (program lines). Implies a potential to add a stage during that mission

Management decision was made not to dispose in higher orbit

INITIAL RESULTS
(midterm)

NO EXISTING STAGES MEET THE NEEDS OF THE MISSION

(For either the HST and ELV launched concepts)

Propulsive forces too high

Deforms or destroys the system, ,making a larger debris problem and an indeterminate flight system configuration

Existing Docking system (Russian) forces too high

Crushes the docking pins and bulkhead

Cost too high and availability difficult to ensure

Existing stages are not configured for rendezvous and STS stages no longer exist.

FINAL RESULTS

Simplified to 8 options

HST operable after installation of stage
HST not operational after installation of stage
Stage installed as part of STS mission
Stage installed as part of ELV launched auto-rendezvous mission

Conclusions

"HST operable" option not viable in this design iteration.

Center of Gravity, stability and power issues

"HST not operable" option viable in this design iteration.

STS installed option simpler but requires servicing mission and provides no subsequent science.

ELV launched auto-rendezvous mission has development requirements for the approach and docking system.

All options range from $250M to $300M *for development only*

CODE SZ POSITION

HST *can* be de-orbited safely by an add-on stage

HST *may* be operable after installation of a stage

- **Requires more detailed stage design activities and potential changes to the HST operations concept and mission restrictions**

The De-orbit stage *can* be installed with an STS mission

The De-orbit stage *may* be installed with an ELV mission

- **Present flight development programs improve the rendezvous and capture technology readiness:** DARPA Orbital Express, NASA DART, DoD XSS-11 and potential Orbital Space Plane investments

SZ is convinced that proceeding with the ELV launched De-orbit stage is the prudent engineering and management decision:

- Allows more time for development of stage
- Decouples cost and manifesting from the HST and STS issues, especially in the out years
- Guarantees multiple options in the event of mission failure
- Can be converted to STS configuration easier than the reverse if design rules are followed

THE WAY AHEAD

Solicit inputs from the contractor community:

- Probably use a Request for Information to get ideas to "flesh out" what the procurement should look like and how to avoid locking out good concepts prior to competition.
- Probably after the beginning of CY 04

Determine the "best" way to acquire the system

Proceed on the schedule driven by the Servicing Mission schedule(s)

- SM4 from mid 05 to 06. Worst case could be 09.
- SM5 might push schedule out further at the risk of reduced funding for the stage development
- SM4 cancellation means an immediate need to redirect funding to development

As always, input from other communities a great help to decision making